

## **APPENDIX C**

### **TECHNICAL STATEMENT OF LEONARD CASCIOLI**

I, Len Cascioli, declare under penalty of perjury that the following is true and correct, to the best of my knowledge, information, and belief:

1. I am Vice President - RF Engineering and Operations at Nextel Communications ("Nextel"). I have been employed by Nextel since 1993 and have worked in the telecommunications industry since 1982. I have had a variety of technical positions at Nextel involving all aspects of Nextel's iDEN wireless technology. Prior to working at Nextel, I was employed by Moffet, Larson and Johnson, P.C., and at LCC, Inc. – both leading communications consultants in the design, implementation and operation of wireless communications networks – as well as at GTE Mobilenet. With 20 years experience in wireless communications network engineering, I am knowledgeable as to all aspects of designing and operating digital and analog wireless systems, including the technical requirements of multiple air interfaces, including AMPS, traditional SMR, GSM, iDEN and IS-136. I hold the degree of Bachelor of Engineering Technology in Industrial Engineering from the University of Dayton, awarded in 1982.
2. In my capacity as Vice President - RF Engineering at Nextel, I lead the Corporate Engineering Team's activities researching, evaluating and responding to complaints of interference from public safety communicators. I also supervise the performance of Nextel's field engineers in responding to specific complaints or concerns. I have been overseeing Nextel's response to CMRS – public safety interference since the first reported instance was brought to my attention in early 1999. Since then, I have directed Nextel's technical investigation of CMRS – public safety interference reports including both lab analyses and detailed interference studies in the field. I have also been responsible for coordinating with Motorola experts representing both its iDEN product and public safety communications products to identify and understand the causes of CMRS – public safety interference and to develop mitigation alternatives. Under my direction, Nextel has developed a comprehensive "How To" guide to provide Nextel's field personnel with consistent direction for information gathering, interference analyses, and mitigation best practices. In July 2001, I authorized an article published in Radio Resource Magazine entitled "Solutions for 800 MHz Interference."
3. I am providing this Technical Statement in support of Nextel's Comments in the Federal Communications Commission ("FCC" or "Commission") Notice of Proposed Rulemaking ("NPRM") in the Matter of Improving Public Safety Communications in the 800 MHz Band, WT Docket 02-55.
4. The first issue I will address is the FCC's statement at paragraph 27 of the NPRM: "It is not intuitively obvious that ... Nextel's... proposed reconfiguration of the 800

MHz band would significantly reduce intermodulation interference.” Nextel disagrees with this statement.

5. In order for an intermodulation (“IM”) product or products formed in a public safety receiver from the presence of strong commercial mobile radio service (“CMRS”) signals to interfere with the desired public-safety transmission, two conditions must be satisfied:
  - a. Energy from the IM product(s) must fall within the receiver passband (i.e. the incoming signals that would create the IM product must be within the receiver’s ability to receive them and the resultant IM product must fall on the desired frequency or very close to it); and
  - b. The strength of the product(s) must be sufficient to lower the ratio of the desired signal strength to the composite interference and noise (the C/I+N ratio) below an acceptable level (e.g. 17 dB for a typical FM radio system).
6. Nextel’s White Paper spectrum realignment proposal would, if implemented, reduce the probability of one or both of these mechanisms occurring by (a) relocating public safety operations out of the 866-869 MHz range and (b) removing the interleaving between public safety and Specialized Mobile Radio (“SMR”) channels in the lower part of the 800 MHz spectrum band.
7. Relocating public safety licensees out of the 866-869 MHz range is necessary because those channels are subject to direct IM-related interference created solely by cellular A - band carriers operating above 869 MHz. Moreover, all current public safety channels between 851 and 869 MHz can receive IM-related interference from (a) Nextel’s use of certain channels below 866 MHz, and (b) the combined transmissions of collocated (or near-collocated) A-band carriers and Nextel. Thus, the White Paper realignment proposal will substantially reduce the number of instances in which an individual CMRS operator can create IM-related interference to 800 MHz public safety systems; it will also minimize interference to public safety systems from collocated CMRS operators.
8. Since the greatest preponderance of Nextel-controlled spectrum is in the range 861-866 MHz, the preponderance of Nextel transmitters at a given site will normally be in that range. IM products produced solely by Nextel transmitters are therefore more likely to involve transmitters in the 861-866 MHz range than Nextel transmitters operating below 861 MHz. It can be shown mathematically that IM products from transmitters in the 861 – 866 MHz range will not fall below 856 MHz and will not fall above 871 MHz. *Removing public safety operations from 866-869 MHz and from being directly adjacent to Nextel on interleaved channels below 861 MHz, therefore, will lower the probability that IM products from Nextel’s operations will fall on a public safety frequency.*

9. The public safety channels between 858 and 869 MHz are vulnerable to direct IM-related interference from cellular A-band systems operating between 869 and 880 MHz, and to IM-related interference from B-band (and A-band) systems operating above 880 MHz. Nextel's internal tests have shown that the bandpass filter in the first stage of the typical public safety receiver provides little attenuation to RF energy at frequencies immediately above 869 MHz. Nextel's tests indicate that the typical first-stage filter attenuates RF signals 3 dB at approximately 873.5 MHz, approximately 8 dB at 880 MHz, and approximately 12 dB at 884 MHz. This aligns closely with the attenuation data provided by Motorola showing a reduction of 3 dB at 873 MHz and approximately 20-25 dB at 894 MHz. *The relatively small amount of attenuation from 869 to 873 MHz means that strong signals from cellular-A Band transmitters in this frequency range can, by themselves, cause IM-related interference in a public safety radio operating in the 865-869 MHz range at levels almost as intense as those generated by transmitters operating in the 861-866 MHz range.* However, signals above 873 MHz will not produce IM products as strong, because the contributing signals are attenuated more by the receiver front-end filter. Thus, if public safety operations are relocated below 861 MHz, it can be shown mathematically that for a cellular A or cellular B-band operator to directly cause an IM-related interference problem to a public safety receiver, at least one of the cellular transmitters involved must be above 877 MHz. *Removing public safety operations from 865-869 MHz will therefore minimize the probability that IM products will cause interference to public safety radio systems by reducing the probability that any IM product generated solely by a cellular A-band or B-band operator will be sufficiently strong to cause interference on a relocated public safety frequency.*
10. Nextel's proposal does NOT preclude the possibility of IM-related interference by the combination of Nextel transmitters and those from collocated cellular A-band or B-band operators. However, if Nextel's proposed spectrum realignment is adopted by the Commission, but the complimentary handset and network improvements Nextel advocates are not implemented, Nextel's proposal will still reduce the probability that IM interference will result from a combination of Nextel's transmitters and co-located cellular A- Band or B- Band operations by limiting the spectrum range over which full-strength IM products will fall. Doing this would require ongoing Nextel spectrum management on co-located sites such that a combined IM product between Nextel and cellular frequencies below 873.5 MHz falls within the Nextel band. This type of ongoing spectrum management is not desirable long-term as it would not provide Nextel the level of flexible spectrum use that other CMRS service providers will have. Thus, Nextel reaffirms its conclusion that public safety handset operating improvements must ultimately be implemented to completely eliminate the risk of IM interference to rebanded public safety licensees from the combined operations of Nextel and collocated cellular A or B band operators.
11. The next issue I will address is the FCC's question in paragraph 27 of the NPRM. The FCC asks whether the intermodulation interference is "...exclusively a function of receiver characteristics, as Nextel contends,..." or whether it is attributable to other causes, and seeks comment on the impact of relocating incumbents far enough away

from the 800 MHz band to remove IM interference as a consideration. As a threshold matter, Nextel did not intend to convey that intermodulation interference is exclusively a function of receiver characteristics. The existence of IM is a function of a number of factors, as discussed below.

12. As stated above, in order for an interfering IM product or products to form in a public safety receiver from the presence of strong CMRS signals, two conditions must be satisfied:
  - a. Energy from the IM product(s) must fall within the receiver passband (i.e. the incoming signals that would create the IM product must be within the receiver's ability to receive them and the resultant IM product must fall on the desired frequency or very close to it); and
  - b. The strength of the product(s) must be sufficient to lower the ratio of the desired signal strength to the composite interference and noise (the C/I+N ratio) below an acceptable level (e.g. 17 dB for a typical FM radio system).
13. Condition (a) is satisfied or not depending on the frequencies of the contributors to the IM product. Condition (b) is satisfied or not depending on several things:
  - a. The strength of the contributors at the receiver input
  - b. The amount of attenuation, if any, afforded by the bandpass filter at the front end of the receiver.
  - c. The linearity of the receiver components up to the first mixer
14. In the case of 866-869 MHz (NPSPAC) frequencies, the transmissions from both CMRS SMR operations in frequencies below 866 MHz and cellular operations above 869 MHz can be aligned spectrally to cause IM products to fall on desired frequencies in the NPSPAC range, (though it is also possible on all Public Safety frequencies). The only way to positively eliminate IM interference as an issue is to either to reduce the sensitivity of public safety receivers to both sets of transmissions (through improvements in IM rejection or through better filtering), or relocate both SMR and cellular operations to frequencies far enough away from the 800 MHz public safety frequencies that they cannot cause IM interference to public safety facilities. With the current frequency arrangement no improvements in receiver front-end filtering are possible (particularly since the top of the NPSPAC range is immediately adjacent to the bottom of the cellular-A spectrum). IM rejection in public safety receivers depends on the amount of electrical current available for the first stages of the receiver. Today's receivers are at or approaching the limits of performance in this area. The only choice remaining is either (a) a reduction in the strength of the contributors, or (b) some form of relocation.
15. As to the first choice, the FCC has received a recommendation from TIA to require CMRS operators to hold their maximum on-street power to a certain level in the 700

MHz range to prevent interference to prospective 700 MHz public safety operators (in the new 24 MHz public safety spectrum). Implementing on-street power reductions for 800 MHz CMRS operators would require CMRS carriers to construct and operate thousands of new additional cell sites to re-establish current coverage contours reduced by the power reduction. Additionally, variations in interpreting the power restriction will cost both public safety entities and CMRS operators substantial resources in coordination and/or argument over measurements. This will drive increases in both the cost of conducting public safety communications AND the cost of providing CMRS services.

16. Nextel's proposal spaces SMR and cellular operations as far from public safety transmissions at 800 MHz as possible AND thereby takes advantage of what limited attenuation current public safety receiver bandpass filters offers to cellular A/B signals. Thus, Nextel's proposal *minimizes to the greatest extent possible the amount of IM interference presented to public safety systems*. It also sets the stage for future public safety radios to be designed to more rigorously attenuate undesired signals through better front-end filtering. It also avoids imposing on public safety operators the burden of wholesale replacement of hardware required if public safety were relocated outside the 800 MHz Band
17. One manufacturer (Motorola) has received FCC approval to sell to public safety agencies a new model radio (the XTS-5000) which according to Motorola will provide NO attenuation to cellular A/B transmissions and may begin to allow RF exposure to 900 MHz paging systems. Implementation of this radio by public safety agencies will expose them to the full energy of cellular A/B transmitters rather than providing even the limited attenuation that current models provide. This will increase the incidence of interference from cellular A and B Band operators to public safety communications systems on the NPSPAC channels. Thus, activation of these receivers will open the door for virtually uncorrectable IM interference to public safety systems under the existing 800 MHz band plan. This is especially true for collocated situations, but will also be a factor for stand-alone cases of IM interference from the cellular A and B – band carriers and Nextel.
18. Due to the current interleaved spectrum allocation at 800 MHz, current public safety receivers are doing what they are designed to do (i.e., hear the entire band). Even if these receivers had a sharper roll-off at the top of the band, the interleaving with Nextel and their close proximity to cellular-A would still create problems. Accordingly, optimum interference management must begin with realignment of the 800 MHz band to relocate all public safety channels into a contiguous block beginning at 806/851 MHz, with cellularized systems migrated to a separate contiguous block starting at the top end of 824/869 MHz and working downward.
19. In its NPRM, at paragraph 73, the Commission asks "...whether 800 MHz band realignment, standing alone, would be sufficient to completely eliminate harmful interference created by CMRS stations to public safety systems, or whether additional palliative measures might be required."

20. Nextel stated in its White Paper proposal that 800 MHz realignment was a necessary but not a sufficient condition to eliminate the current interference. As noted above, the Nextel proposal minimizes the potential for such interference with the current generation of hardware and sets the stage for receiver improvements to eliminate it. Nextel believes that additional steps are essential to eliminate the interference to public safety. These steps should include, but may not be limited to, enhancements to public safety handset receivers and CMRS transmitter filters. More robust public safety system deployments would also reduce the potential for interference.
21. The current receiver standards in TIA-603 and related documents are measured near the receiver noise floor. While this was adequate in the past, the RF environment has changed and this measurement technique is no longer adequate in and of itself. In particular, receivers should be characterized over their entire dynamic range, not just at the noise floor. Additionally, the current receiver standards in TIA-603 do not provide any characterization of the receiver front-end bandpass filter, whereas the lack of receiver front-end filtering is a major component of the current interference problem. The absence of receiver front end filtering standards will be an even more acute interference contributor if radios such as the dual band 700/800 MHz XTS-5000 – which fails to attenuate adjacent channel RF energy up through the cellular B-Band channels – are sold to and placed in service by public safety communications operators.
22. Nextel also notes that some public safety mobile data systems and their receivers are being designed in such a manner as to be more susceptible to interference than public safety voice systems. Discussions with vendors and analysis of these systems indicates that they typically require a  $C/(I+N)$  ratio of 25 dB or greater (30 dB in some instances) to perform adequately. The typical voice system requires a  $C/(I+N)$  of 17 dB. The more stringent  $C/I+N$  requirement appears to be driven by (a) the greater potential for the RF link between the mobile data terminal and a serving base station to fade destructively (i.e. fade such that portions of the message are irretrievably lost) during the time that a message is sent from the base station to the mobile data terminal combined with (b) the fact that a computer, rather than a human ear and brain, is attempting to decode the received signal. These factors make the increased  $C/I+N$  requirement reasonable in and of itself; however, the implemented system design must be robust enough to maintain this elevated  $C/I+N$  in the actual environment the system must operate in.
23. Nextel has been involved in trouble shooting interference to a number of public safety data systems, some of which have been only recently implemented. In some of these locations the associated 800 MHz voice system is adequate while the data systems exposed to the same noise and interference potential are not able to complete transfers of data. It appears, based on our experiences in this area that, rather than compensating for the known greater  $C/I+N$  requirement and the current state of the RF environment by providing more robust on-street signal strength and by adjusting message lengths and protocols to compensate for the current RF environment (and accepting some reduced throughput in the mobile data system), the system designers

continue to assume that the only possible noise or interference source to be considered in the design of these systems is the internal thermal noise of the mobile data receivers. This assumption is unwarranted and illustrates why Commission-adopted public safety system and receiver performance standards are necessary and would help solve the CMRS – public safety interference problem.

24. The FCC has also solicited comment on (a) imposing more stringent limits on OOB emissions of CMRS transmitters, (b) whether or not a composite OOB limit can be set for all transmitters installed at a given site, (c) how aggregate OOB signals would be calculated or measured, and (d) whether more stringent OOB limits should be imposed retroactively on transmitters currently in operation.
25. Nextel supports a more stringent OOB limit of  $-80$  dBc/25 kHz at 500 kHz from the edge of the authorized band of operation, assuming that public safety and CMRS spectrum are no longer interleaved as they are today. Under today's 800 MHz spectrum plan, current combining technology cannot produce sufficient roll-off of OOB to allow for success in the interleaved spectrum. For this measurement, the noise measurement bandwidth should be the same as the carrier bandwidth.
26. Setting a composite OOB limit for all CMRS transmitters at a given site is at best problematic for the following reasons:
  - a. When multiple CMRS carriers are co-located, the aggregate noise at the site will rise as individual carriers install additional transmitters or modify their operating technology. Enacting a fixed OOB noise standard at the site means that all operators will have to continuously improve their technology at a given site even if they are not adding any services at the site. This is an extra financial burden on all operators.
  - b. Identifying sites that are out of OOB compliance will drive costs upward. This would require either (a) that any change at a site be coordinated through a third party responsible for monitoring compliance with the regulation or (b) that a third party be continuously spot-checking for compliance. Both methods will require extra resources to accomplish and will discourage the deployment of new technologies due to the extra cost for back-end regulatory compliance.
  - c. If a site is identified to be out of OOB compliance, adjudication of which parties are liable for correcting the error will be difficult and resource consuming. This is another extra financial burden on all operators.
27. Moreover, the primary cause of interference to public safety communications is IM interference, with OOB being a distinctly secondary (though still potentially major) cause of interference. Accordingly, the most effective and efficient approach to eliminate OOB is to realign the 800 MHz band as proposed in Nextel's *White Paper*. Nextel's proposal, by rearranging the spectrum to remove the interleaving between public safety and CMRS activities, allows for much more aggressive

filtering of OOB, since filters will no longer have to be adjusted for every possible combination of public safety and CMRS frequencies. Assuming 800 MHz realignment is implemented as Nextel proposed, the improvements in transmitter filtering made possible by this realignment will render OOB a non-issue in almost every case.

28. Any new OOB limits should not be universally imposed retroactively on existing transmitter operations. As indicated above, operators may need to install additional filters to eliminate OOB in certain specific locations. They will be the best judges of when and where installation is required at existing sites.
29. The FCC also requests comment on the level of public safety signal required to provide a "...significant mitigation of interference..." when public safety mobile or portable units are operating in the vicinity of a cellular or cellular architecture digital SMR base station. Based on experiences in a number of cases, Nextel believes that a sufficiently robust signal, based on current-generation portable radios and FM voice modulation, is approximately -70 to -75 dBm if no IM interference is present, and assuming a 17 dB carrier / (noise + interference) ratio. This signal level provides good in-building coverage for public safety systems without the necessity in many cases of dedicated in-building coverage enhancements, thereby making it desirable for public safety systems to have this robust a signal level in any case. In today's environment Nextel has seen cases of IM related interference where the CMRS signal level is weaker than -40 dBm. With the implementation of a system with the signal levels noted above, a CMRS signal level would need to be stronger than -40 dBm for IM related interference to be present. Thus the radius of interference around a CMRS site that potentially has IM related interference would be significantly reduced. If receiver enhancements are implemented as Nextel recommends, IM-related interference will be virtually eliminated.
30. The FCC has also requested comment on the necessity of a guard band at 800 MHz between the proposed new public safety channel block and the digital SMR cellularized channel block. A minimum guard band of 2 MHz (2 MHz on both the uplink and downlink frequencies for a total of 4 MHz) between the CMRS systems and a typical high site public safety system is necessary. This guard band provides for a couple of benefits in regards to interference mitigation. The first benefit is that it allows for the elimination of noise related interference due to OOB from a CMRS carrier. A CMRS carrier can implement a transmit filter that will sufficiently reduce its signal outside of the 2 MHz such that noise related interference can be eliminated.
31. Including a guard band will reduce the potential for IM interference to the Public Safety systems outside of the guard band with current receivers. The greatest potential for IM interference is in spectrum directly adjacent to CMRS. Therefore, the probability of IM interference outside of the guard band is lower than inside of it. If receiver standards are adopted for public safety receivers, the 2 MHz guard band will allow for the development of a receive filter that attenuates over this 2 MHz so

that CMRS signals can not create IM products within the receivers within the usable spectrum of Public Safety.

By: /s/ Leonard Cascioli\_\_\_\_\_

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